New tweeter for the 2.5 clone

After introducing the 2 kHz notch filter to the original crossover (v2) design and also introducing a slightly modified filter (v3) in order to smooth frequency and phase response in the upper midrange, still people have been complaining about the sibilant nature of the upper registers. I have defended the 8513 tweeter, being such a proven design, and have hesitated to make any changes to the tweeter as this would most certainly for good take us away from the ProAc Response 2.5 sound with its strengths and weaknesses.
However, I cannot ignore the fact that a number of my recordings linger on my CD-shelf as long as the clones are in place in my living room, this mostly being records of vocal music.
But first a short story on the tweaks that have been conducted in order to get to the decision of introducing a new tweeter.

DAMAR coating

A series of near field measurements of the 8535 were done in order to localize cone break-up and not surprisingly the dust cap is responsible for some serious cone break-ups that create a significant bump at 2 kHz (fig. 1) (same place as the bump created by the crossover).
Two layers of DAMAR coating were applied to the center dome and this to some extent smoothed the frequency response in the upper midrange (fig. 2) and also above 10 kHz. Subjectively this had a positive effect on the overall perceived sound.

Damping the 8535 Dust Cap (diyaudio.com), Darryl Nixon and Troels Gravesen.

Recent experiments by Troels Gravesen have demonstrated that there are advantages in applying damping to the dust cap of the clone's 8535 mid-bass driver. Troels has been working on the resonance problems of the 8535 which he found has "a major intrinsic bump at 3 KHz". In Troels' words, ". . . the coating seems to remove some edginess in the midrange with a more smooth performance and tolerance towards difficult recordings".

The substance used is Damar varnish, which can be obtained from artists' supply shops. The picture attached is from Troels and is of Damar as sold in Denmark. The following is reported with Troels' permission, together with quotes from his e-mails to me.

"As a start you may apply a coating until the dust cap is soaked and leave it there as long as it is not applied outside the dust cap. The effect should be there in a couple of hours . . .

"At the beginning of applying the DAMAR the somewhat porous dust cap readily absorbs the varnish and I continued to apply DAMAR until the surface appeared shining. This doesn't mean 'flooded' with liquid, so 'soaked' may be a little overstated. Actually the amount of DAMAR applied is moderate. I should have applied it in mikrolitre quantities to give recommendations. However, after drying the application is hardly visible. After 1 hour I repeated the application with a final coat of 'less than first time'. After 1 week I don't measure altered performance, so I guess the treatment is stable over time. If the coating is to be removed the dust cap is soaked with turpentine and absorbed with Kleenex tissue."

The varnish sold under the "Damar" brand name in my own country is produced by the company Art Spectrum, and the 100mL bottle I obtained looks physically different. Also, the consistency of the substance is obviously thicker than that sold in Denmark. Applying it as Troels recommended did not produce the same visual results he described. The varnish did not really soak into the dust cap as I applied it, but produced a shiny appearance from the outset. Nevertheless, I went ahead and applied a moderate amount. It took several hours to dry, though it remained slightly sticky in places even 18 hours later. (Mind you, it had been raining here for several days, so that may explain the drying time.) It eventually soaked in to a large extent, though there were still some shiny patches. I reported this to Troels and he recommended the following:
"If your Damar batch seems to be rather thick I'd hesitate to apply a second layer of coating. Maybe one additional layer at the 'center of the centerdome', like 2 cm diameter. Uneven distribution of coating is usually a good thing in disturbing resonances."

My listening tests produced similar results to Troels'. There is a small but definite reduction in midrange edginess, giving a slightly cleaner sound in what I consider to be the clone's main problem area. This benefits "difficult" recordings in particular, so if you are troubled by the clones' midrange this is a highly recommended mod. Just don't expect miracles! The effect is subtle.

The important thing is that you don't apply too much (though the coating is reasonably easy to remove with turpentine if you do) – and that you DON'T get any on the cone itself. (Troels did try damping the cone with Damar, but the results were very negative.)

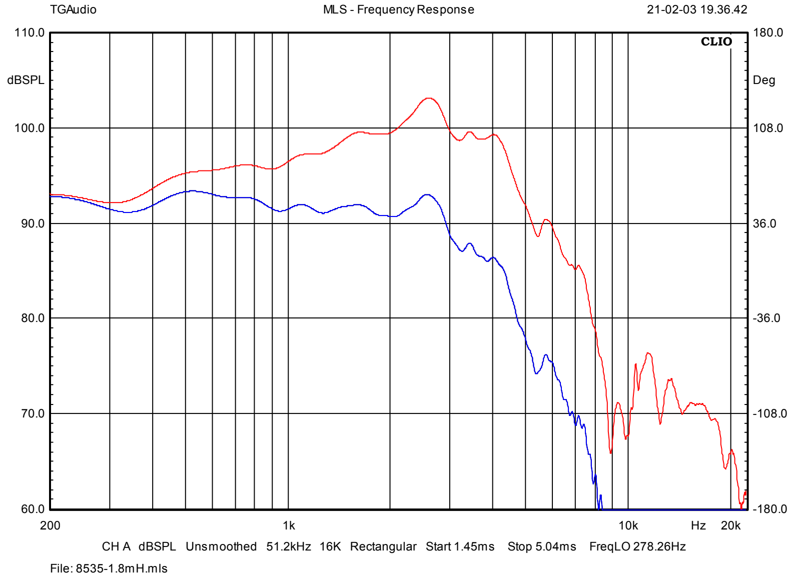

Fig.1, red = 8535 in cabinet, no crossover. Blue = 1.8 mH in series with 8535. No smoothing.

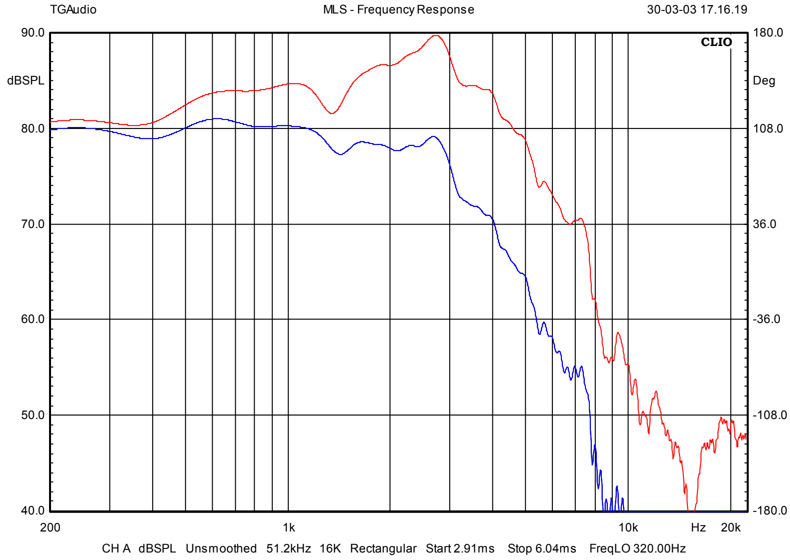

Fig.2. Red = 8535 after DAMAR coating, no filter. Blue = 8535 after DAMAR coating + 1.8 mH.

Identifying the source of sibilance

First the clones were cut off below 100 Hz by a 6 dB filter and supplemented by a subwoofer in order to significantly reduce cone movement and ease the burden put on the 8535 by having to reproduce everything from 30 Hz to 3 kHz.
This did not in any way reduce the sibilant nature of the highs. Excessive cone movement does not seem to be a severe limiting factor for the 8535 in order to truthfully reproduce the sensitive midrange except when played at very high level.

Secondly a 3-way construction was tried introducing a Vifa PL11MH coated midrange at 500–3000 Hz. This is indeed a very good midrange and I wouldn’t hesitate to use this in some other construction. This did not – much to my surprise – in any way change the sibilant nature of the highs! After this there was only one thing left to do: ‘Thanks to the 8513 tweeter for all the hours we have spent together, but out you go!’
Having a pair of ScanSpeak 9500s, this was an obvious choice for a new pair of tweeters.
I have removed the magnetic oil in the voice coil gap of the 9500s. Otherwise no tweaks.

Construction of a new crossover

LP-section: You can reuse most of your components from the v3 crossover in this new filter. The 1.8 and 0.47 mH coils are the same. The capacitor has been raised to 8.3 uF (6.8+1.5) and a 2R2 resistor has been added to the capacitor giving a smooth roll-off for the 8535. The point of crossover is intended to be around 3 kHz, as I'm now confident that the 8535 will do well all the way to this point and I want to maintain the 8535 handling as much of the midrange as possible.

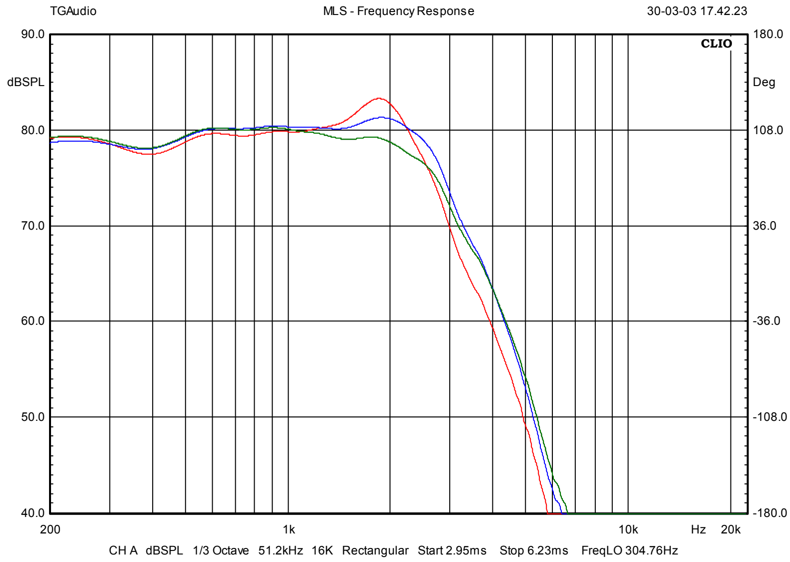

Fig. 3. 8535 roll-off with various filters:
Red = 1.8 mH + 8.3 uF + 0.83 mH
Blue = 1.8 mH + 8.3 uF + 0.47 mH
Green = 1.8 mH + (8.3 uF+2R2) + 0.47 mH. All 0.33 oct. smoothing.

The basic 3rd order crossover topology is maintained in order to give best possible phase response in the crossover region.
<u>As can be seen, the need for the 2 kHz notch filter is eliminated by this approach.</u>

HP-section:

Not much to say about this part. No problem in making the 9500 roll off at 3 kHz. See schematics, fig. 4 and response curves fig. 5 and 6.

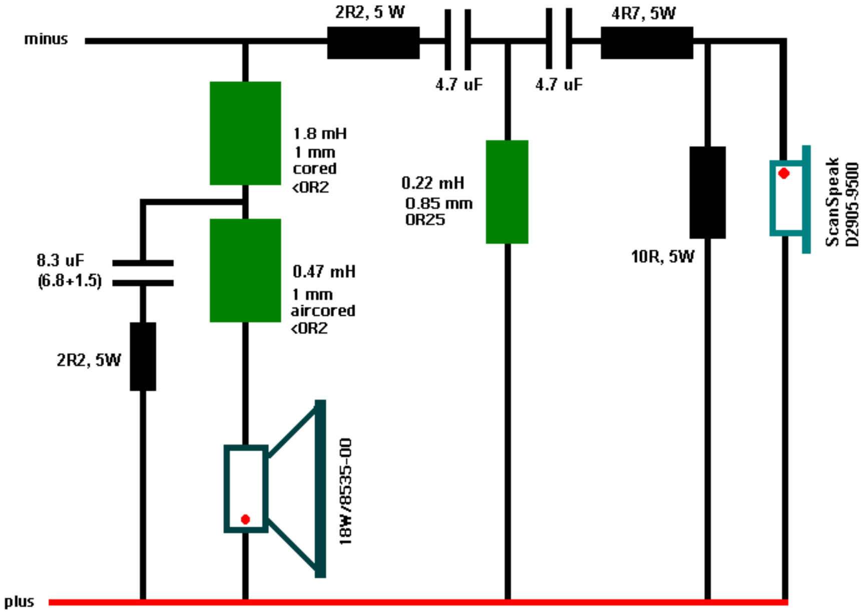

Fig. 4. Crossover schematics for 8535+9500.

Fig. 5 displays the frequency response from the drivers with the new filter and with same polarity a dip is seen at crossover frequency.

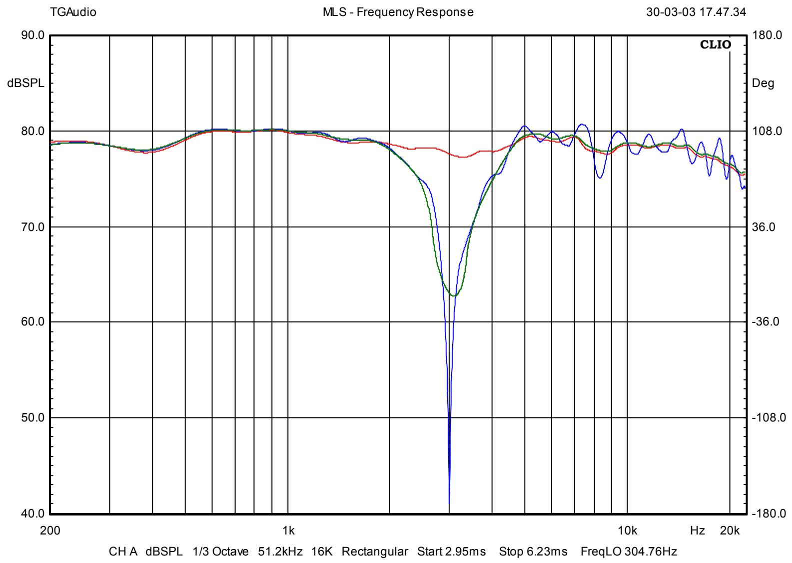

Fig. 5. Red = frequency response with inverted polarity, 0.33 oct. smoothing. Green = same polarity, 0.33 oct. smoothing. Blue = same polarity, no smoothing. All measurements performed at tweeter height, 1 meter distance.

I'm quite sure tweeter level will be an issue and the 2R2 can be changed from 1–2.2 ohms resistance without affecting point of crossover.

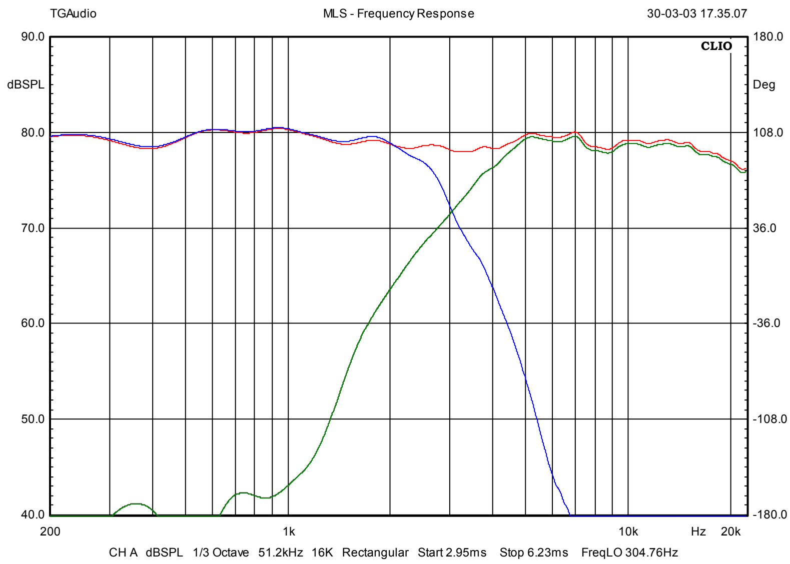

Fig. 6. Roll-off of both drivers with new filter.

Graphic presentation of new crossover for bi-wiring:

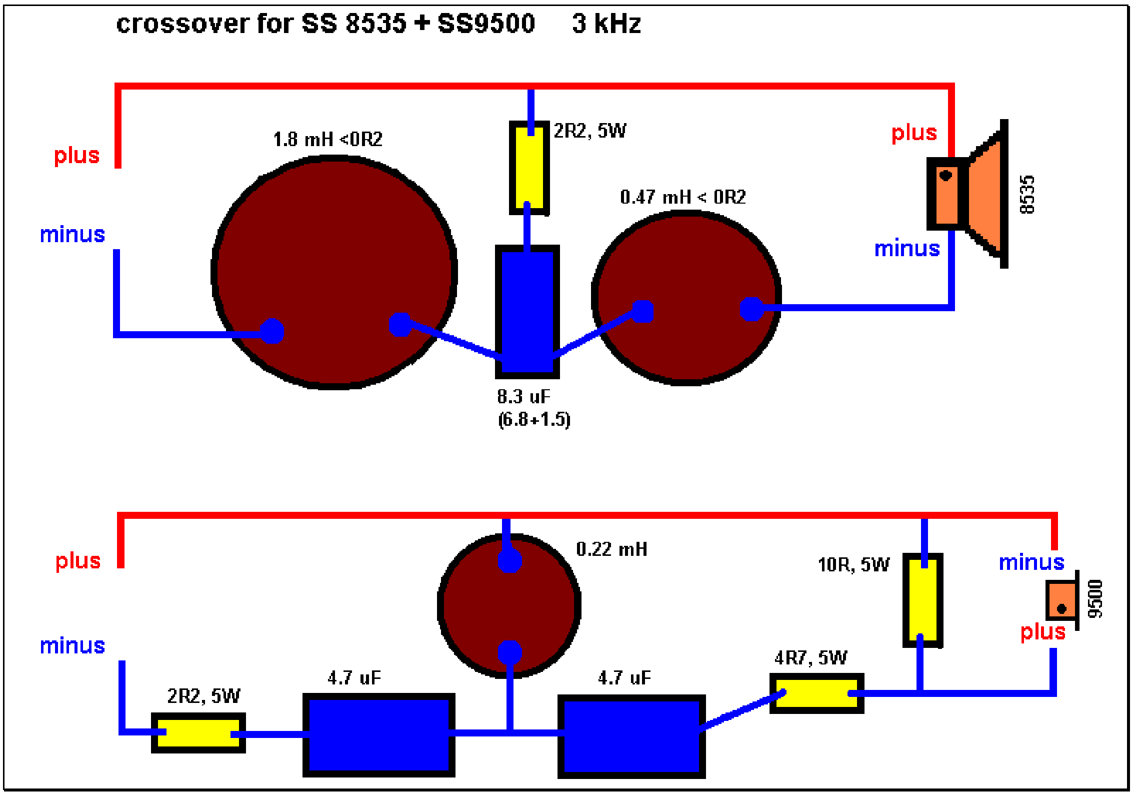

Fig. 7. Crossover schematic, layout for bi-wiring.

Sonic evaluation of modified 2.5 clone

The 9500s have the ability to bring forward the best qualities in the 8535s and the word that first comes to my mind is coherence. To my ears the 8535 has a kind of old-fashioned full-range sound, yet in a completely other league than the old PHILIPS 9710 'full'ranger' or the like.
It has its 'virtues' in terms of a rather robust midrange that is quite demanding on your choice of recordings. It is rather merciless on poor recordings and inadequate electronics and will probably always be so.

With the new tweeter in place the degree of transparency rises considerably and we know how much the low end adds to the sense of transparency, and the 8535 has that ability, so we are close to getting it all from this modest two-way floorstander. Quite amazing. The new design appears to give a slightly more distant perspective and for sure the sibilant, whizzer sound is gone.

I think that the elimination of the notch filter by redesigning the LP section does a great deal to enhance transparency. Notch filters can 'solve' acute problems, but I still have the feeling they can add some obscure/subtle phasiness to the region affected.
Looking at the CSD data from the region where the notch filter works, it looks like we have to look <u>over</u> a hilltop to spot the start of the transient, meaning that despite having an apparent flat frequency response it seems as if the energy is slightly delayed (page 6, latest v5) in the region affected by the notch filter.
Ideally we want only the forefront of the sound wave to hit the ear followed by an immediate decay within the first 0.5 milliseconds.

The 9500s seem to have a slightly recessed high end (> 10kHz) compared to the 8513s, despite having a very flat frequency response, and I believe this is a very common observed phenomenon with most 1" soft-domes.

2.5 clone with ScanSpeak D2905-9500 tweeter.

2.5 clone setup

The aim of this chapter is to present some experiments done on setting up the 2.5 clones in my living room in order to achieve the best possible sound. The dimensions of the room are 380 (W) x 560 (L) x 230/260 (H) and it has a rather unusual cross-section as seen from the drawing, fig. 8:

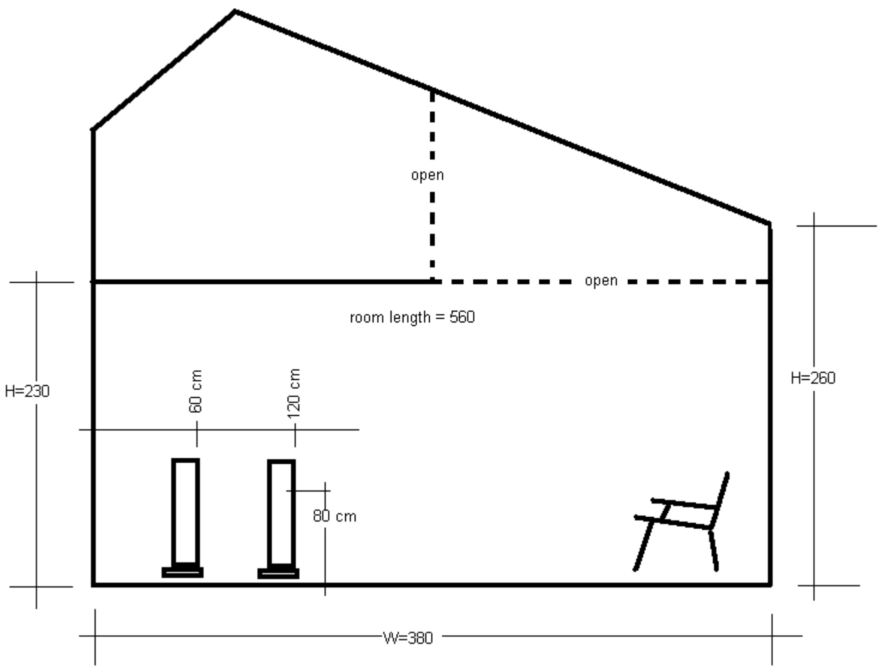

Fig.8. Cross-section of listening room.

With the speakers placed along the longest dimension of the room under the lower part of the ceiling I will regard the room as being 380(W) x 230(H) x 560(L) cm. (12.5' x 7.5' x 18.4') in calculations to come.

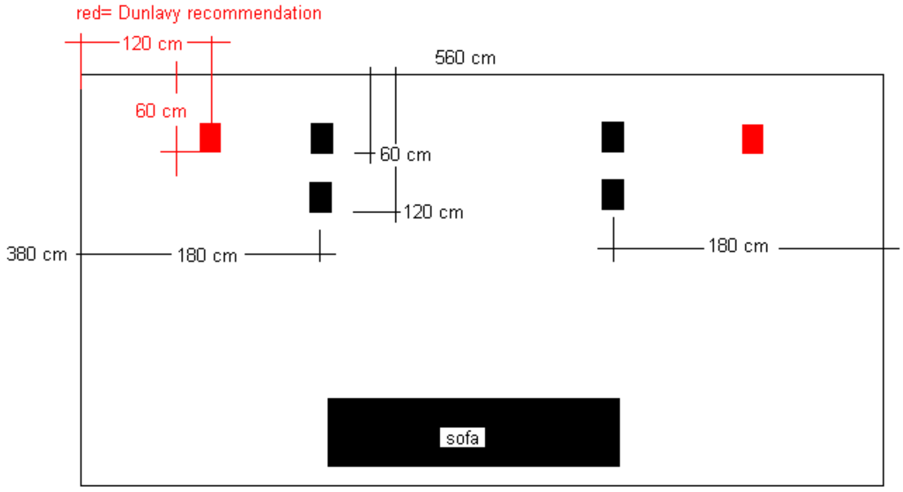

Fig. 9. Speaker placement in listening room. Speakers toed in at listening position to cross over behind listener's head.

According to Joseph D'Appolito[1] this is close to the ideal listening room (445(W) x 243(H) x 567(L) cm). I very much recommend reading chapter 4 from his magnificent book.
Had I known when I built my house, I would have added 65 cm to the width of the living room!
Another fine source of information is the website of John Dunlavy. Dunlavy's recommendations are 8' x 13' x 20'.

Dunlavy:

One of the longest-running myths in the audiophile industry that certainly needs to be set straight is that loudspeakers should always radiate along the longest dimension of the listening room.

Simple acoustical analysis shows that this configuration yields a narrow soundstage and a lumpy bass-spectrum. This is because the sound reflected off the wall behind the listener creates a standing wave pattern that results in peaks and nulls in the low-bass response at the listening position. In addition, the entire end of the room behind the listener may actually behave as a resonant chamber with potentially deleterious consequences for reproduction of sound at the low-end of the spectrum.

Couldn't agree more.

It is usually best if the distance of a loudspeaker from the side-wall does not equal the distance to the back wall. If a loudspeaker is located equidistant from both the side and back walls. the distance being measured from the center of the front-surface to the relevant reflection point on the wall, a symmetrical cavity is formed. This may create enhancements of as much as 6 dB at some frequencies, resulting in a degradation of perceived sound quality, especially in the upper-bass and lower-mid ranges. Best overall response is usually obtained when the distance of the loudspeaker from the side-wall is either larger or smaller than the distance of the loudspeaker from the back-wall. This will prevent reinforcements of peaks and valleys from occurring at the same set of frequencies, thereby smoothing the overall frequency response of the system. For a typical room of average size, e.g. 8 feet high, 13 feet wide and 20 feet long and a listening distance of from 8 to 12 feet, a good starting distance between the loudspeakers and the back-wall would be approximately 1 1/2 to 2 feet and a distance to the side walls of about 3 to 4 feet.

Well, 1.5–2 feet from the back wall is close and – come on Dunlavy – you would not place the speakers 3–4 feet (1 meter) from the side walls (= room end walls), leaving the speakers 4 meters apart with a listening distance of approx. 3 meters! In my room this creates a significant hole in the middle of the sound scenario.
I'd recommend at least 1.5 meters to the side walls with this setup and a listening distance of ~2.5–3 meters.

Last but not least, the website of Jochim Gerhard[3] from Audio Physic is another source of information on speaker setup and acoustical perception.
However, it appears that Jochim Gerhard is setting up loudspeakers at the end wall of the listening room, quite close to the side walls which are partly covered with some heavy sound absorbing material in order to reduce side wall reflections, like 1 m^2.
When I place my speakers like this they sound quite terrible! Try for yourself.

The first reason for taking a closer look at speaker setup was a small EXCEL program found at http://members.chello.se/jpo/, 'bassandroom'.
JPO has put together a quite useful program, that will give you an idea of how your speakers are going to perform as a result of a given positioning in your listening room.
The nice thing about JPO's design is that it takes into account the actual drivers' TS parameters.
The second reason was that several people have reported lack of energy in lower midrange/upper bass, and Zoltan Almasi from Hungary mailed me measurements that confirmed this phenomenon.

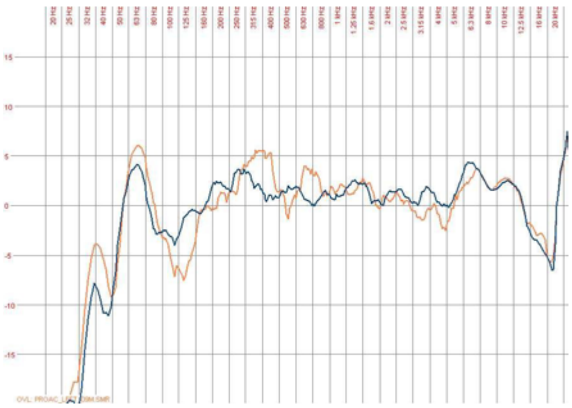

Fig. 10. Zoltan measurements, response dip at ~125 Hz.

Simulated response of clone in listening room:

Woofer:	
Vas (l)	46
Fs (Hz)	32
Qts	0.45
Re (ohm)	5.9
Series res (ohm)	0.4
Qtsn	0.48050847
Closed box:	
Vb (l)	33
Qtc	0.74346003
Fc (Hz)	49.5115536
F3 (Hz)	47.208606
Qr	1.54723605
Vr	1.39393939
Vented box:	
Vb (l)	33
Fb (Hz)	42
Ql	7
F3 (Hz)	37.0354214
Vent diam (cm)	6.9
Vent length (cm)	14.2203232
Woofer placement:	
Dist to floor (cm)	80
Dist to front wall (cm)	60
Dist to side wall (cm)	180

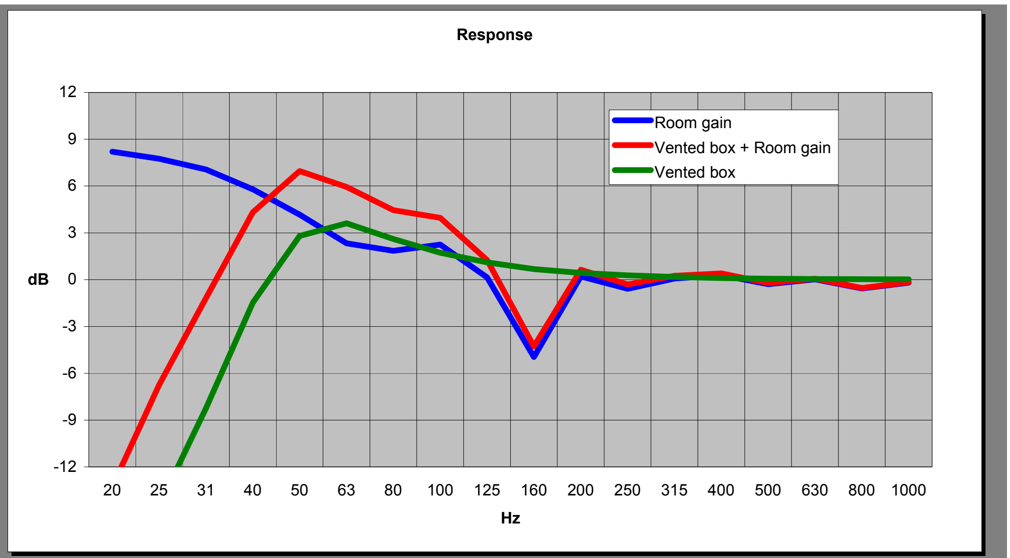

Fig.11. 'standard' setup in my listening room. 60 cm from front of cabinet to back wall. 180 cm to side walls, driver 80 cm above floor level. As can be seen, a severe dip at ~150 Hz is the result of this placement. How does this correlate to real life measurements?

Response measurements of 2.5 clone in listening room:

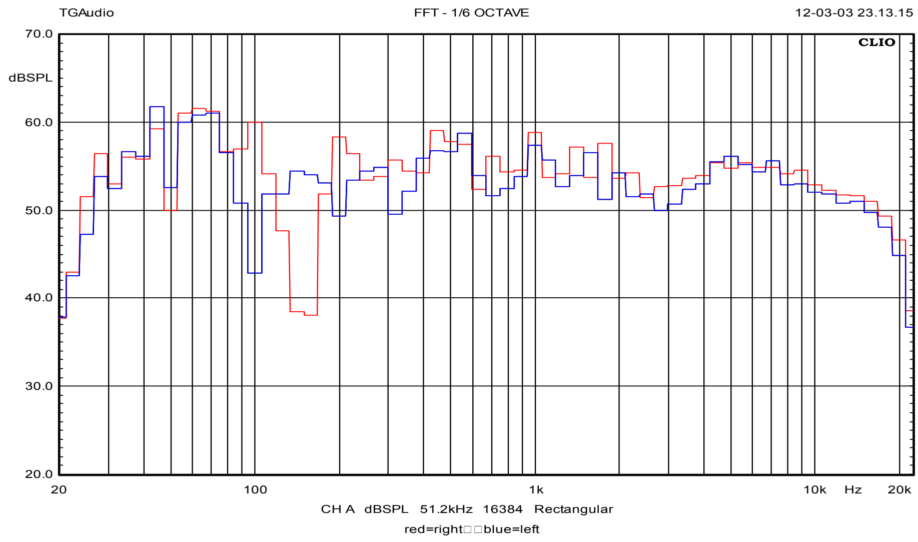

Fig. 12. FFT 1/6 oct. measurements performed in listening room. Red = right speaker, blue = left speaker. Response measured at 2.5 meter distance = listening position.

For the right speaker the prediction of response seems to work fine, where the left speaker displays a more linear response.
It has been argued that this lack of energy was related to the actual performance of the 2.5 clone, which I have had a hard time believing, but it also appears that the 8535 has an excessive bass response from 50–100 Hz, which is well predicted from box simulation – green curve, fig. 11 – and if we to some extent set the listening level based on bass performance we may very well perceive the overall response as deficient in the upper bass register.

Woofer:	
Vas (l)	46
Fs (Hz)	32
Qts	0.45
Re (ohm)	5.9
Series res (ohm)	0.4
Qtsn	0.48050847
Closed box:	
Vb (l)	33
Qtc	0.74346003
Fc (Hz)	49.5115536
F3 (Hz)	47.208606
Qr	1.54723605
Vr	1.39393939
Vented box:	
Vb (l)	33
Fb (Hz)	42
Ql	7
F3 (Hz)	37.0354214
Vent diam (cm)	6.9
Vent length (cm)	14.2203232
Woofer placement:	
Dist to floor (cm)	80
Dist to front wall (cm)	110
Dist to side wall (cm)	180

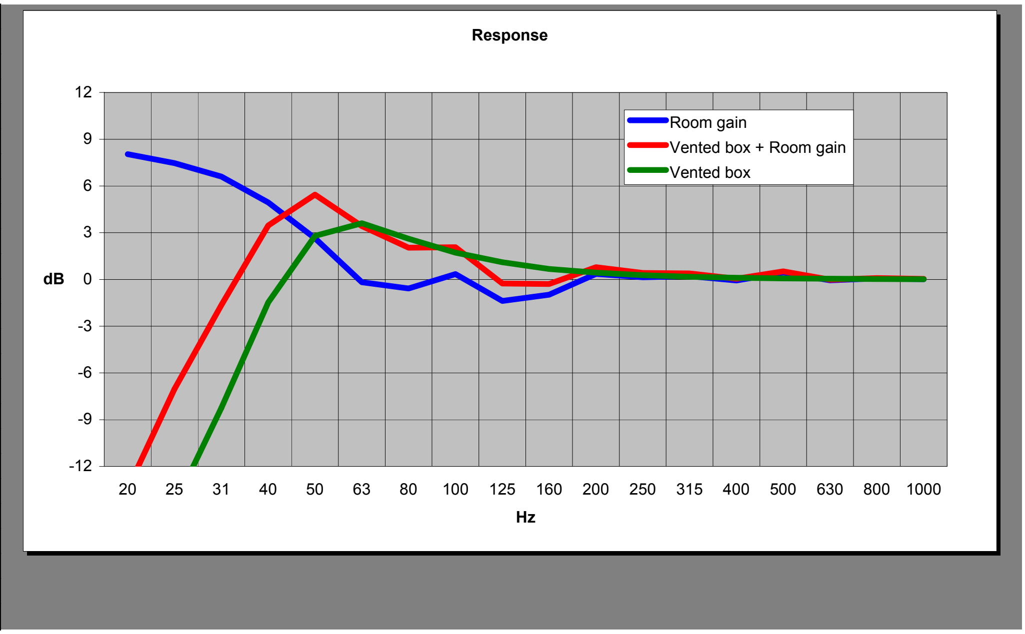

Fig.13. Prediction of response with driver 80 cm above floor level, 110 cm from back wall and 180 cm from side walls.
With this kind of positioning (fig. 9) I get a rather flat response in the 100–200 Hz range, but still 5 dB excessive level at 50 Hz.

So done I had the best sound from the clones ever! Subjectively the very low end was reduced slightly, and I probably had a better 100–200 Hz response from my right speaker. The degree of transparency increased significantly and I could hear things I had not heard before. Playing the

'jazz at the Pawnshop' (FIM XRCD012-013) audiophile 'pressing' gave an in-there experience I haven't heard before. This was like sitting at the 1st or 2nd row with the saxophone right up to your face. And at high levels it still sounded clean and most enjoyable. Did this placement really do something to the edginess in midrange and tweeter sibilance?? Changed to some jazz female singers and well, maybe to some extent, but not quite all the way.
I suppose a more correct frequency response derived from optimal positioning in general enhances the performance of any speaker, but does not eliminate the midrange hardness associated with the 8535 driver (listening tests with 8513 still in place).

Darryl in Australia tried the same thing and here are his comments:

I found some time today to look at the spreadsheet. I put in your figures first. Wow! I wish I had a room like yours. When I plugged in the positions I'd been using, there was a very large dip at 125 Hz – so much for doing it by ear! Anyway, I played around with various figures and came up with a reasonable compromise, given my room dimensions and furniture. I used 120 cm from the back wall and 70 cm from the side walls. Compared with your own positions, this gives some unevenness in the response and a peak in the lower bass, around 3dB above what you achieved – but at least the dip was gone. (Anyway, you can put these figures in for yourself and take a look.) And guess what? Suddenly there was "body" in the sound. Wonderful! And I agree – this was the best sound I've heard from the clones as well, but I'm sure yours sound better!

Frequency response of right speaker across listening area

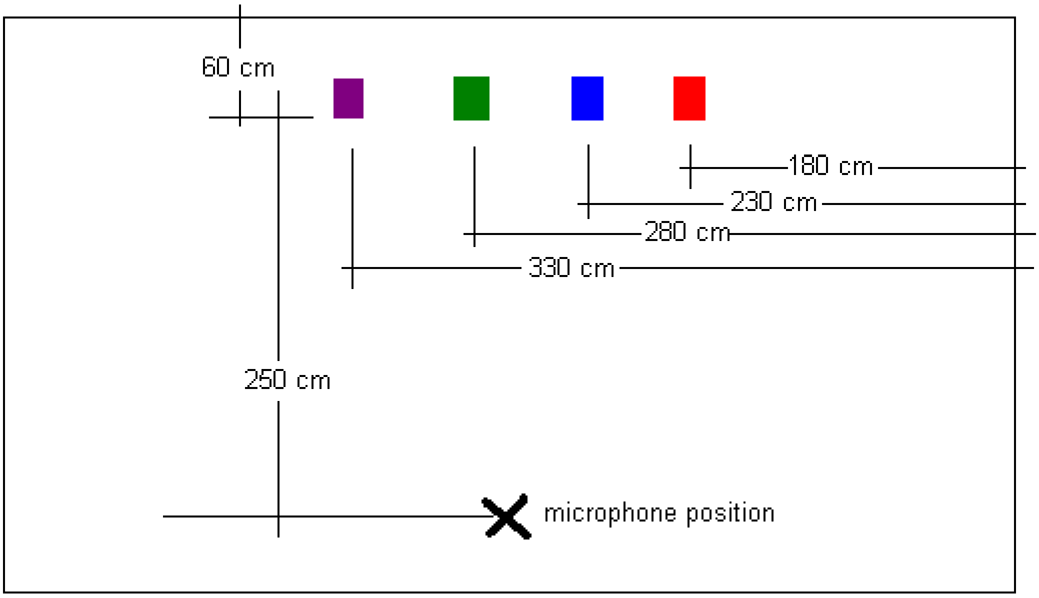

Fig.14. Speaker positioning in room.

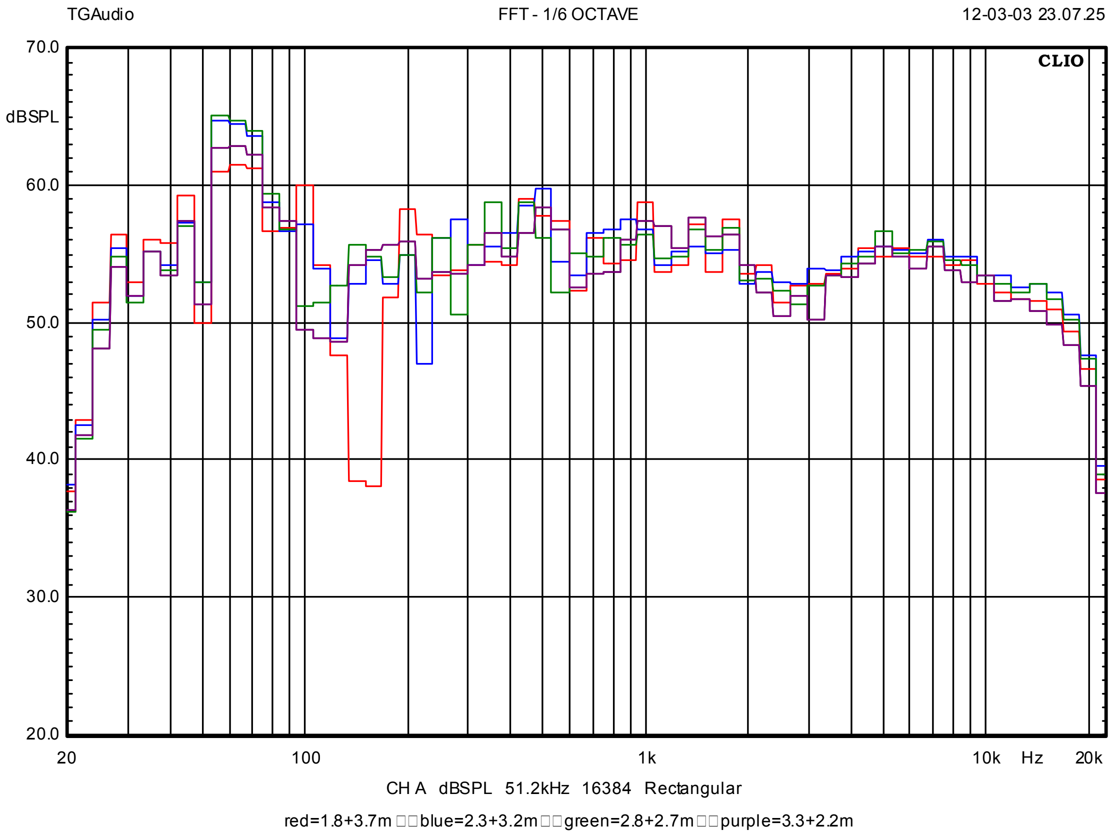

Fig.15. Room response at various distances from right wall.

Apparently I have a significant dip in response of the right speaker, which is strange as this performance is not seen with the left speaker, but left speaker is 190 cm from left wall and there's some furniture in the corner left to the speaker, which may account for some reduction in distance.

Predicted performance of left speaker:

Woofer:	
Vas (l)	46
Fs (Hz)	32
Qts	0.45
Re (ohm)	5.9
Series res (ohm)	0.4
Qtsn	0.48050847
Closed box:	
Vb (l)	33
Qtc	0.74346003
Fc (Hz)	49.5115536
F3 (Hz)	47.208606
Qr	1.54723605
Vr	1.39393939
Vented box:	
Vb (l)	33
Fb (Hz)	42
Ql	7
F3 (Hz)	37.0354214
Vent diam (cm)	6.9
Vent length (cm)	14.2203232
Woofer placement:	
Dist to floor (cm)	80
Dist to front wall (cm)	60
Dist to side wall (cm)	190

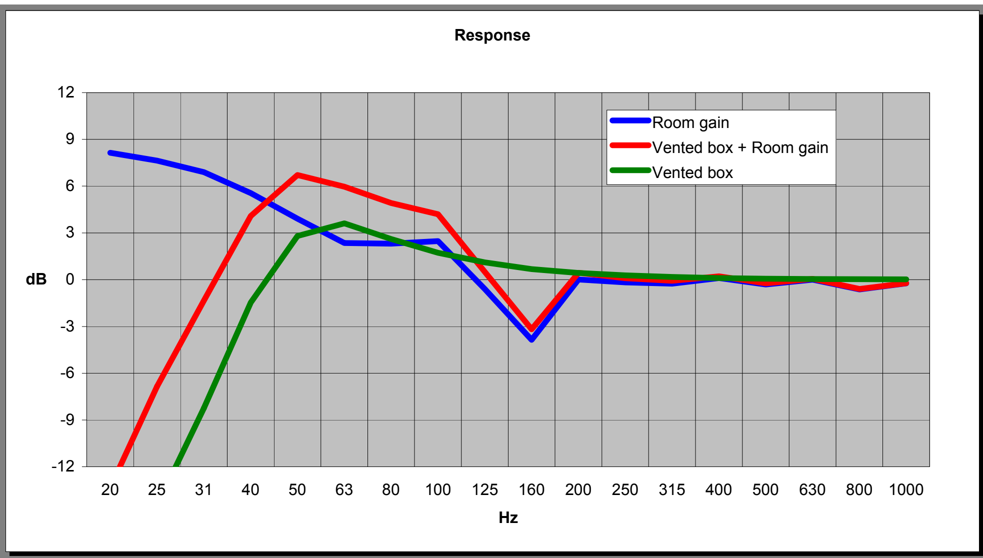

Fig. 16: left speaker 190 cm from left wall.

Woofer:	
Vas (l)	46
Fs (Hz)	32
Qts	0.45
Re (ohm)	5.9
Series res (ohm)	0.4
Qtsn	0.48050847
Closed box:	
Vb (l)	33
Qtc	0.74346003
Fc (Hz)	49.5115536
F3 (Hz)	47.208606
Qr	1.54723605
Vr	1.39393939
Vented box:	
Vb (l)	33
Fb (Hz)	42
Ql	7
F3 (Hz)	37.0354214
Vent diam (cm)	6.9
Vent length (cm)	14.2203232
Woofer placement:	
Dist to floor (cm)	80
Dist to front wall (cm)	60
Dist to side wall (cm)	150

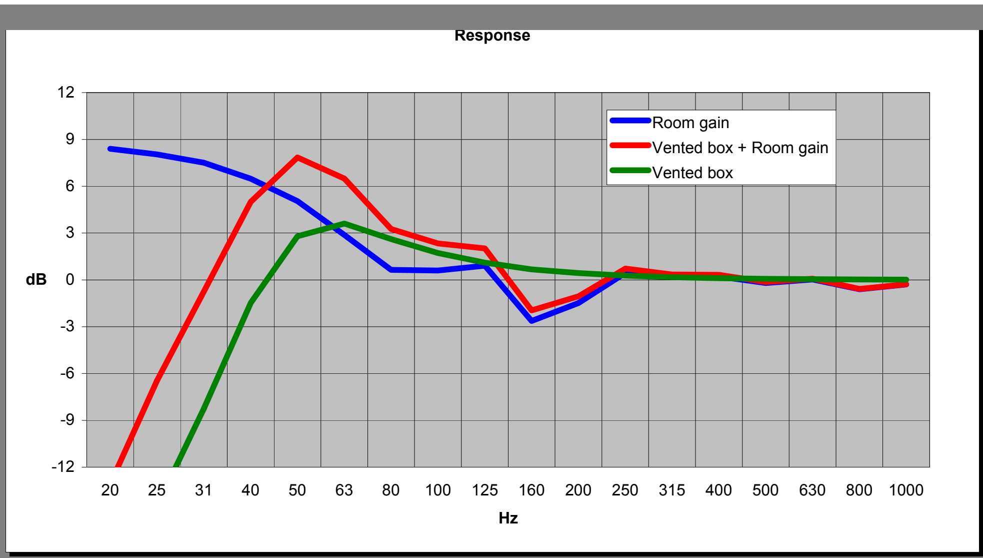

Fig.17: left speaker at estimated 150 cm from left wall. Reduced level at 80–125 Hz, but still a dip at 160 Hz.

I believe that if we have a rather ‘clean’ room, this spreadsheet can give us ideas of how to position our speakers to perform better.
The spreadsheet does not include room dimensions, reflection coefficients of walls/floor/ceiling, placement of vent in cabinet and lots of other things. Presumably it was developed for subwoofers usually placed close to the floor which with this setup do not necessarily have to be corrected for room dimensions.

A more sophisticated spreadsheet is found at:
http://www.pvconsultants.com/audio/reflection/downloads/room060d.exe
This spreadsheet takes room dimensions and reflection coefficients (RC) into account but does not provide examples of reflection coefficients. I believe that a RC=1 goes for a fully reverberant room, where RC=0.1 is close to an anechoic chamber giving a ruler flat response. Response is seriously affected by reflection coefficients. The spreadsheet does not take into account the TS data of the driver and box used with this driver.
Try for yourself and see if it makes sense.

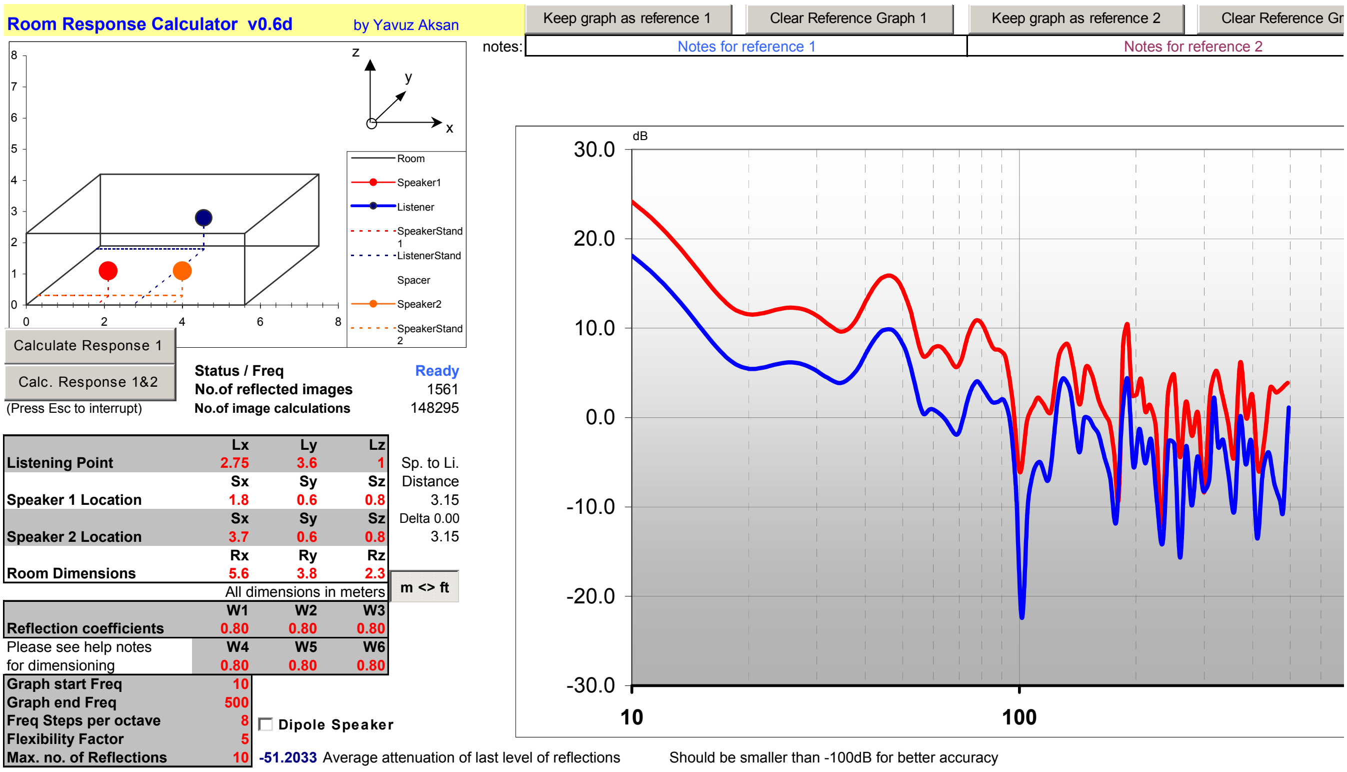

Fig. 18. Predicted response of 2.5 clones at 'standard' position in listening room.
Blue = right speaker, red = both speakers.

This gives a somewhat more confusing picture and I haven't been able to use this calculation sheet constructively. Any suggestions will be welcome.

Thanks to Darryl Nixon for all contributions and for proofreading the paper!

Thanks to JPO at members.chello.se/jpo/ for lending the space on his website and for giving me access to his 'bassandroom' EXCEL sheet.

Thanks to Zoltan Almasi for commenting on 'listening' room response.

Troels Gravesen
troels.gravesen@danisco.com

[1] Joseph D'Appolito: Testing Loudspeakers, page 56.
[2] John Dunlavy: Listening Room Considerations. http://www.dunlavyaudio.com/index.html
[3] Audio Physic website: http://www.audiophysic.de/produkte/aufstellung/aufstellung_e2.html